



A New ETL 449 MHz Wind Profiler for TARS



Scott McLaughlin

Daniel Wolfe

NOAA's Environmental Technology Laboratory

February 4, 2002

Boulder, Colorado

Feb. 4, 2002

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Wind Profiler for TARS

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From original presentation given Feb. 4, 2002

Presentation regarding newly developed/integrated radar wind profiler developed for use by Air Force to support Aerostat.

Team Members

■ Air Force

- Stan Zduniak
- Richard Hayton
- Robert Esser

■ Lockheed-Martin

- Paul Lambridies
- Jeff Porter

■ FSL

- Margot Ackley
- Doug Van De Kamp
- Leon Benjamin

■ ETL

- Scott McLaughlin
- Dan Wolfe
- Tom Ayers
- Bob Weber
- Dave Welsh
- Dave Merritt
- Dan Law
- Jim Jordan
- Karen Martin
- Dick Strauch
- Matt James
- Rich Lataitis
- M.J. Post
- Al Bedard

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Persons directly involved in getting the project going and producing good results.



Sponsor

United States Air Force

Air Combat Command

Program Management Squadron

Tethered Aerostat Radar System (TARS)

Langley, Virginia

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Sponsor

TARS



- "The primary mission of TARS is to provide critical low- altitude radar surveillance of the southern approaches into the US and selected areas of the Caribbean. This program supports air sovereignty and counter-drug operations conducted by DoD (North American Aerospace Defense Command and US Atlantic Command) and Law Enforcement Agencies (US Customs Service and US Coast Guard)." [<http://www2.acc.af.mil/lg/cons/lgco/tars.htm>]

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As quoted...

TARS Sites



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Do to budget cuts, a few of these may be closing.

TARS Sites



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Pictures

ETL History with TARS Part I

- 404 MHz Profiler El/Az Yagi Antenna
 - 1988: Strauch, Moran, Bedard, Nishiyama, Merritt
 - Real-time winds and Acceleration of RASS development
- 915 MHz
 - 1990 or 1991: Jordan
- Procurement Package developed
 - Developed in mid 1990's, then cancelled...

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ETL has worked with the TARS program going back to at least 1988. A 404 MHz wind profiler was installed at Ft. Huachuca, AZ for almost a year providing real-time winds. A 915 MHz system was also tested. Later, in the mid 1990's, ETL developed a procurement package to purchase several wind profilers. This procurement effort was later cancelled.



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ETL 404 MHz Radar Wind Profiler set up several miles from the TARS site. The antenna was composed of multiple Yagi antennas, positioned on a elevation-over-azimuth mount. The mount would reposition the antenna once every minute to collect horizontal wind profiles.



404 MHz radar tests were also conducted at the TARS site.

ETL History with TARS Part II

- ETL Aerostat Weather Workshop
 - 1998, Bedard
- ETL 449 MHz Tests at Ft Huachuca
- "Aerostat Meteorological Hazards Handbook"
 - Feb. 2001, Bedard
- MOU with ETL for 449 MHz wind profiler
 - 1999, Post
- ET4 449 MHz Tests at Ft Huachuca
 - Oct. 1999
- Operational 449 MHz Radar Wind Installed
 - Oct. 2001

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Al Bedard (of ETL) organized a workshop at ETL to bring flight directors and others concerned with aerostat flight safety together. With this new kick-off for improved weather support technology, a handbook was produced, and eventually a 449 MHz profiler was permanently installed at Ft. Huachuca for real-time winds support.

Oct 1999



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In 2000, a portable ETL 449 MHz system was also temporarily setup at the TARS site to test for interference and to see if winds could be acquired if the radar was located directly at the TARS site.

The background of the slide features a dark, atmospheric image. In the upper half, a large, light-colored blimp or airship is visible against a dark sky. In the lower half, there is a silhouette of a radar station or a similar large-scale facility with various antennas and structures, set against a lighter, possibly hazy or snowy, ground.

Partnership Benefits

- Air Force does not have to become Radar Wind Profiler Experts
- NOAA/NWS obtain quality data in data-sparse regions
- NOAA/ETL are able to stay abreast of and implement latest techniques for RWP's

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Benefits to tax payer and to involved government agencies.

Direct NOAA Impacts



■ Improve:

- Knowledge of Hurricane Dynamics
- Hurricane Landfall Forecasts
- Southwest Monsoon Flow Forecasts
- Midwest Severe Storm Forecasts
- Gulf Coast Severe Weather Forecasts
- Regional and Seasonal Predictive Climate Models

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The new profilers can greatly aid in NOAA's mission to forecast severe weather events and seasonal change.

The background of the slide features a dark, atmospheric image. In the upper half, a large, light-colored blimp or airship is visible against a dark sky. In the lower half, a large array of solar panels is laid out on a flat, possibly desert, landscape. A small, distant structure, possibly a radio tower or antenna, is visible on the horizon.

Requirements

- Real-time High Quality Winds
 - Highest possible temporal and spatial resolution
 - 4 km minimum height coverage
 - User friendly Displays
- Low Cost and Reliable w/Minimal Maintenance
- Commercial Off-the-Shelf Components

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Basic requirements desired by the Air Force.

Final Design I



- ETL acts as prime integrator
 - Assess and Use Latest Technology
- 449 MHz System
 - to guarantee height coverage
- Almost all commercial off-the-shelf (COTS) components
- 2-kW peak power transmitter

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ETL would act as system integrator, carefully selecting all major components and using as many COTS components as possible. The focus would be on reliability, maintainability, and high quality wind data.

Final Design II

- Vaisala/CRADA radar components
 - (Receiver, Interface, Dwell Engine LAPXM_{TM})
- 18-element coaxial-collinear antenna
- Weber et al., Signal Processing System
- TARS Site Real-time Data Interface
- Hardware Monitor System

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A CRADA (Cooperative Research and Development Agreement) was established almost 10 years ago to transfer ETL (and other local NOAA laboratory's) radar wind profiler technology to the private sector. Many components used in the new 449 are derived from this original CRDA. Additionally, ETL derived advanced signal processing for wind profilers would be used to provide high quality winds to the flight directors.

Boulder Integration and Testing



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All fabrication, integration, testing, and initial collection of data took place in Boulder, CO.



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The final system came together in Boulder, CO the winter/spring of 2001. Testing was conducted throughout the year. When the Ft. Huachuca site infrastructure was finally in place, the system was installed October 2001.

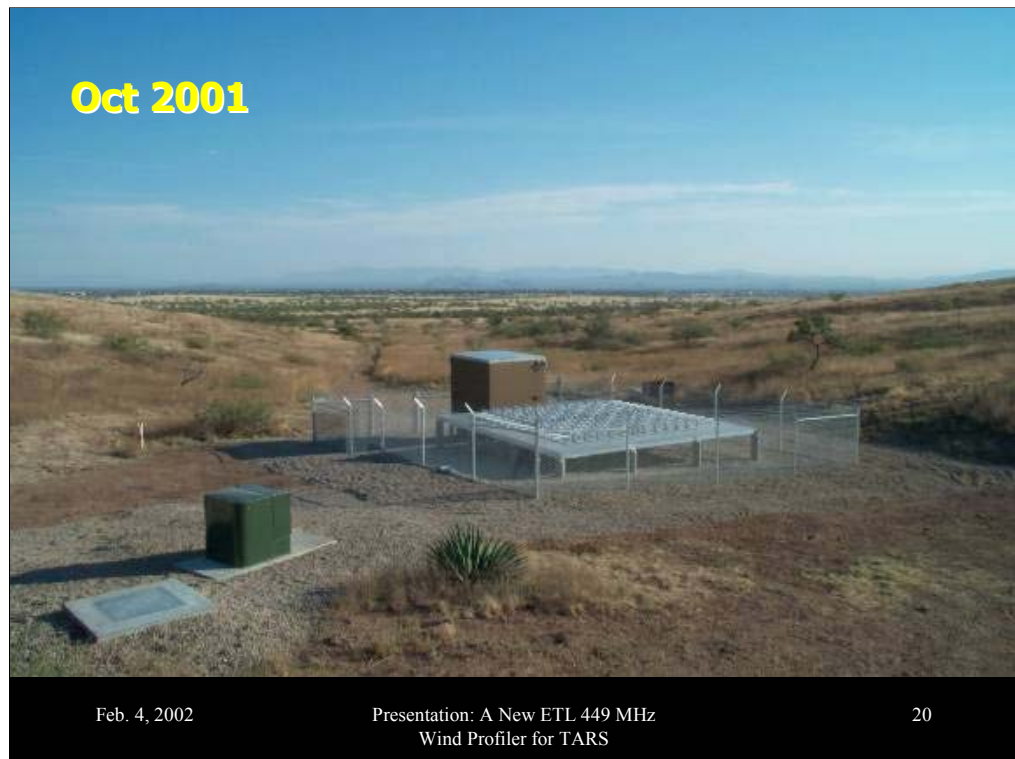


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View of site from above on surrounding hill. Sierra Vista is in the background, the TARS site in behind and to the right about 2 miles.



Final installation. Sierra Vista is in the background looking to the ENE



Final installation. Aerostat is approximately 2 miles away. Looking to the SW

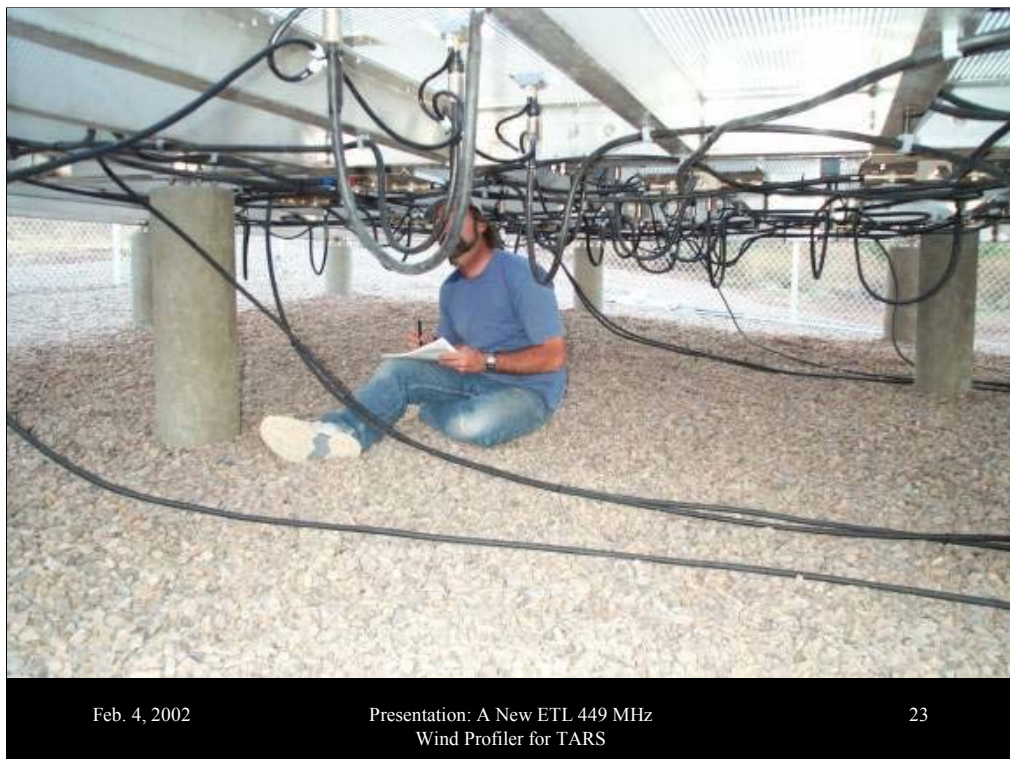


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Close-up of antenna. Antenna is composed of 2 orthogonal arrays. Each array is composed of 12 antenna stick. An antenna stick is composed of 18 dipole elements assembled in a coaxial-collinear fashion.



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Underside of antenna showing the RF cable feed network and air dehydrator lines.



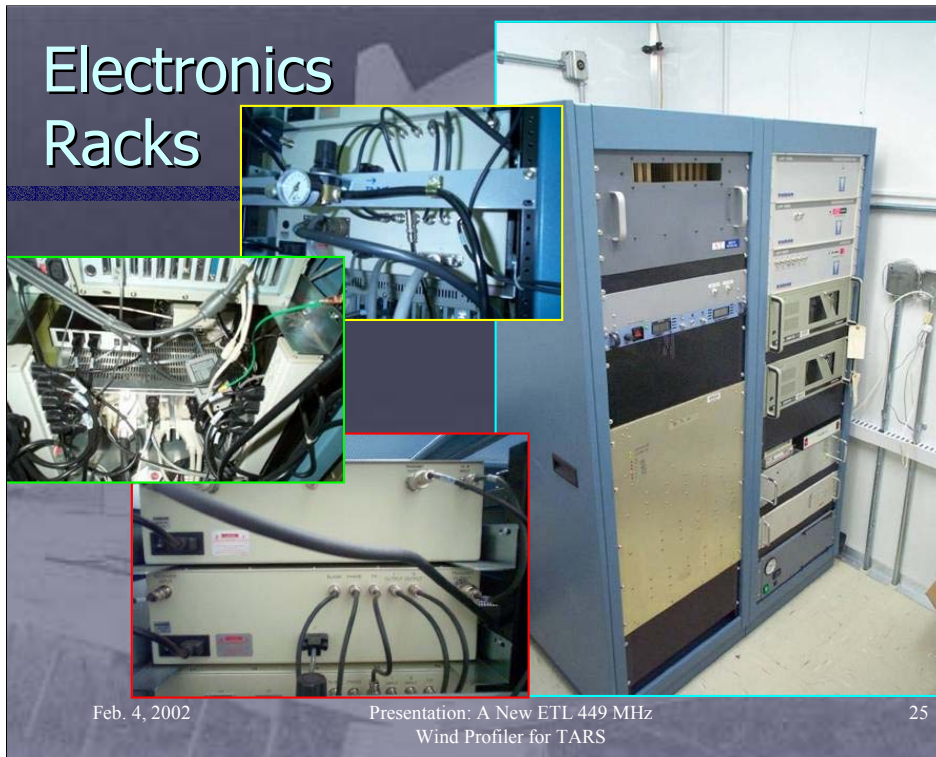
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Close-up of high-power RF 2-way dividers.

Electronics Racks



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Interior of 8x12 foot shelter. All system components are located in two electronics racks.

Dehydrator, UPS, and BSU



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The system utilizes a UPS backup and a air dehydrator. The Beam Steering Unit (BSU) is responsible for phasing the RF signal to allow pointing of the radar beam.

Environmental



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View of air conditioner controller, in-line surge suppressor, circuit breakers, and air conditioners. Also a portion of the interior grounding halo can be seen.

Final Amplifer



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2-kW peak, with four 500 W units for redundancy and soft-fail capability.

New 6-Way Divider with Monitoring



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New ETL 6-way divider design incorporating temperature sensors on the reflect loads. By measuring these temperatures, the health of the antenna, cables, dividers, and beam steering unit can be determined.

Hardware Monitor and Communications



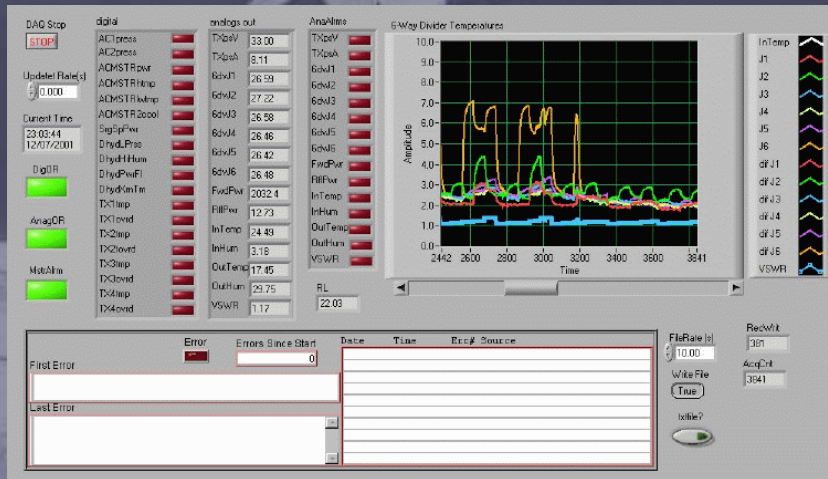
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Hardware Monitor chassis. Contains power supplies and interconnects.

Hardware Monitor Display



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Hardware Monitor Display showing all measured parameters and a graph of the temperature difference between the 6-way divider loads and ambient temperature. This indicates that there is some power being reflected back from the antenna.

ETL Advanced Signal Processing System (SPS)

- Developed by Weber, Wuertz, Wilfong, Welsh, Merritt, and Wolfe

- **Multi-dimensional database coupled with:**

- Multiple-signal Detection
- Moments Calculation
- Signal Identification
- Meteorological Products Calculation
- Graphical Displays

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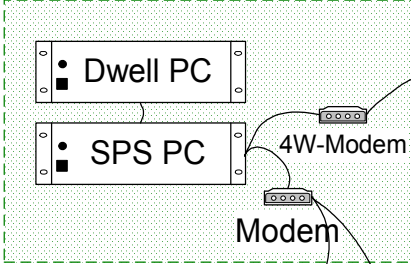
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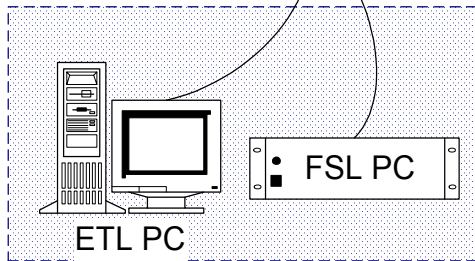
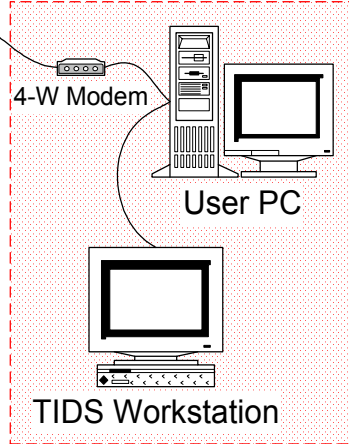
New advanced ETL signal processing, not currently commercially available.
Screens out interfering signals to allow calculation of high time resolution winds.

449 MHz RWP Data Flow and Control

Radar Site



TARS Site



Boulder or other Remote Site

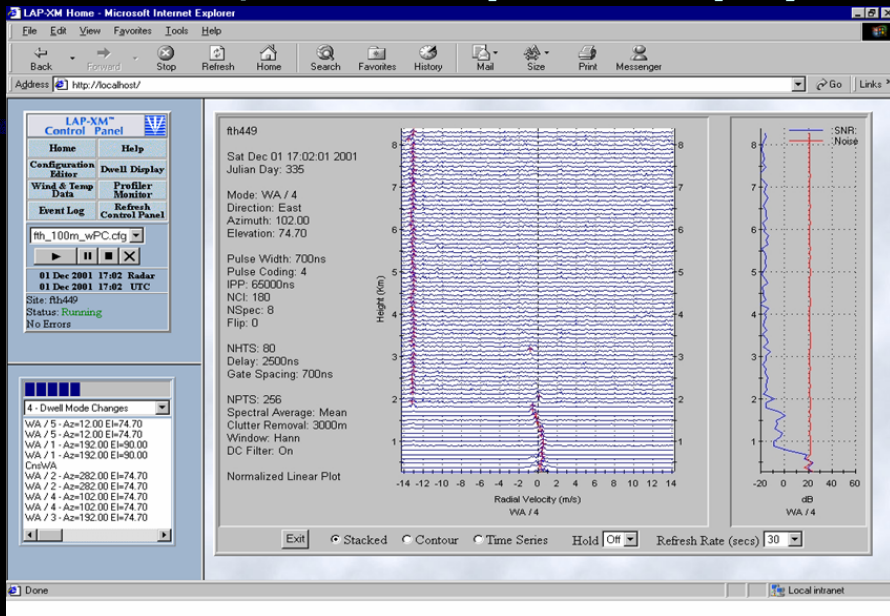
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Basic external data flow diagram for 449 MHz radar.

Dwell PC, LAP-XM Spectra Display



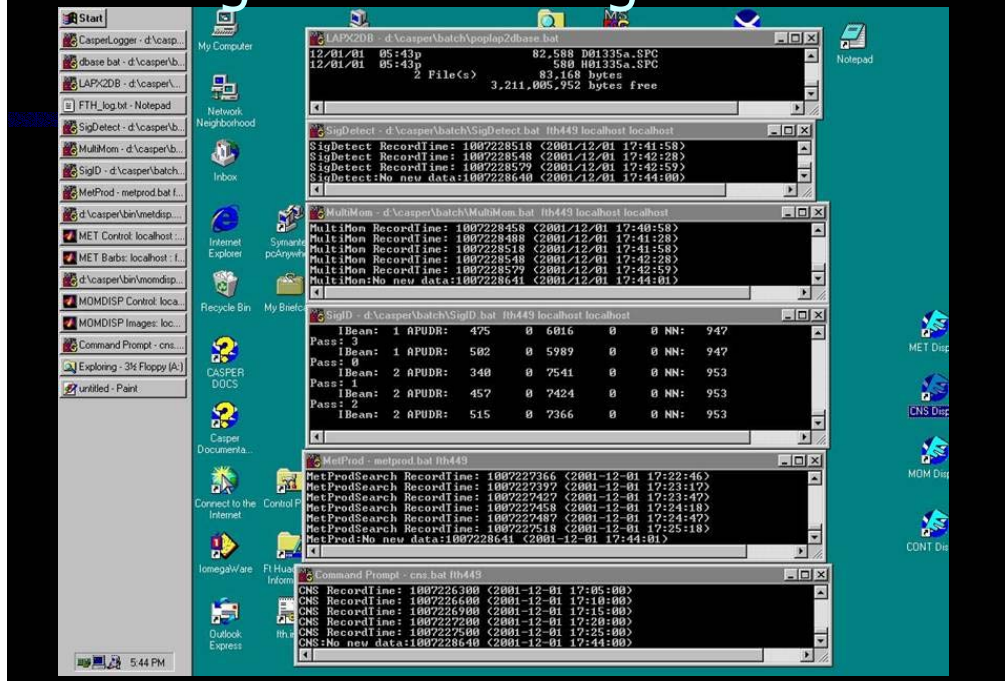
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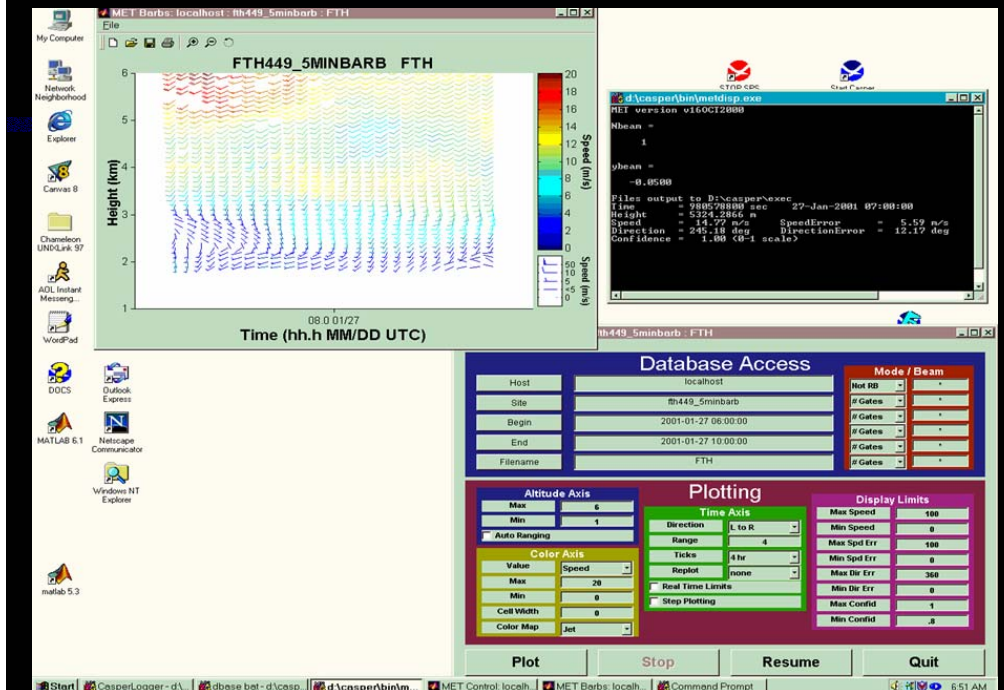
Normal view of Dwell PC at radar site. The spectra show good wind spectra eventually being covered with interference from RFI- common at both Boulder and the Ft. Huachuca site.

Signal Processing PC



Normal view of Signal Processing PC located at 449 MHz radar. Open command windows are outputs intermediate outputs of various signal processing routines.

Ft. H User PC



Normal view of User PC located at TARS site. The wind barb window is normally expanded. Data is also fed to the TIDS.

Profiler Testing and Validation at BAO

- CNS & SPS Time Resolution
- Tower Comparison

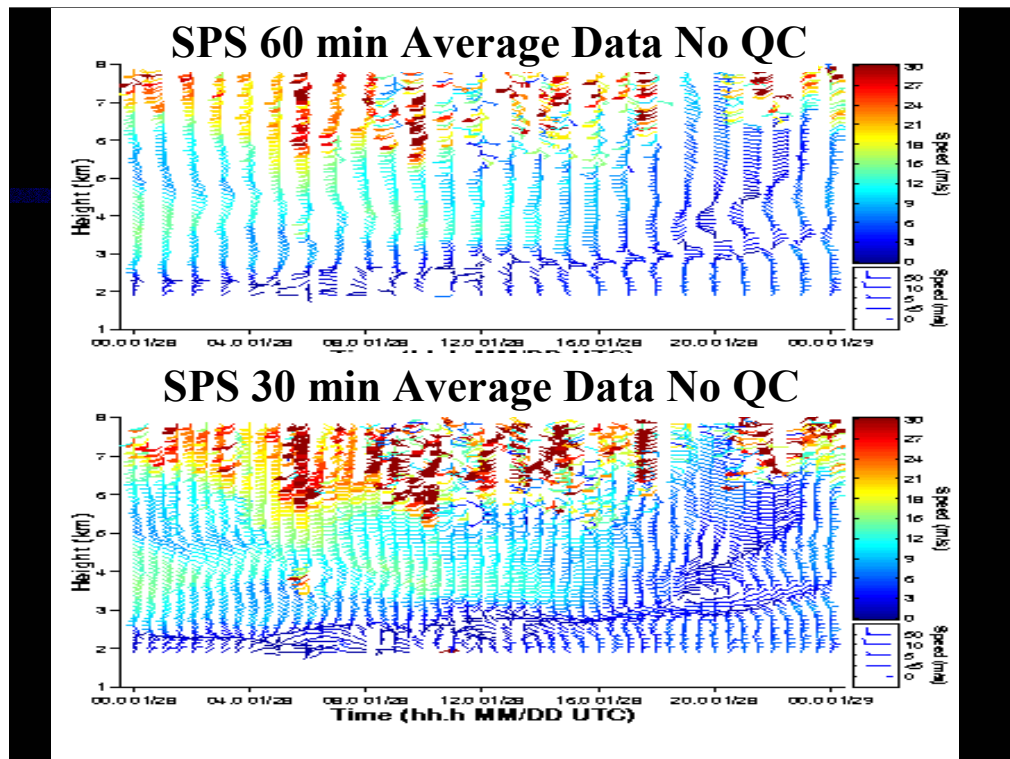


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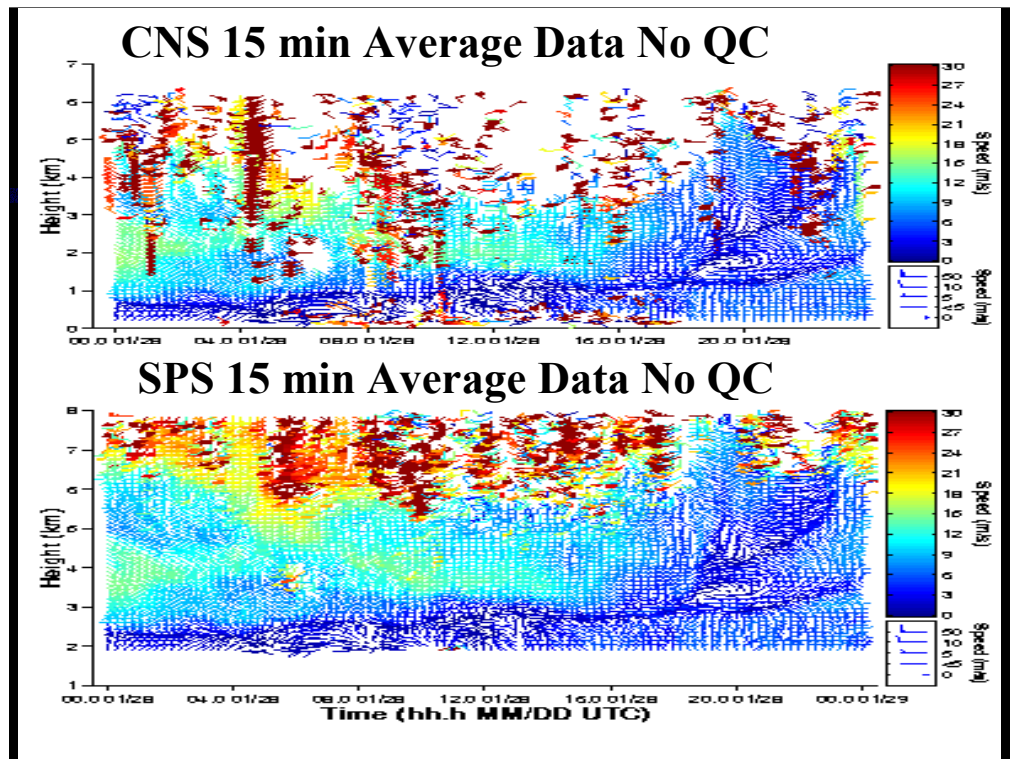
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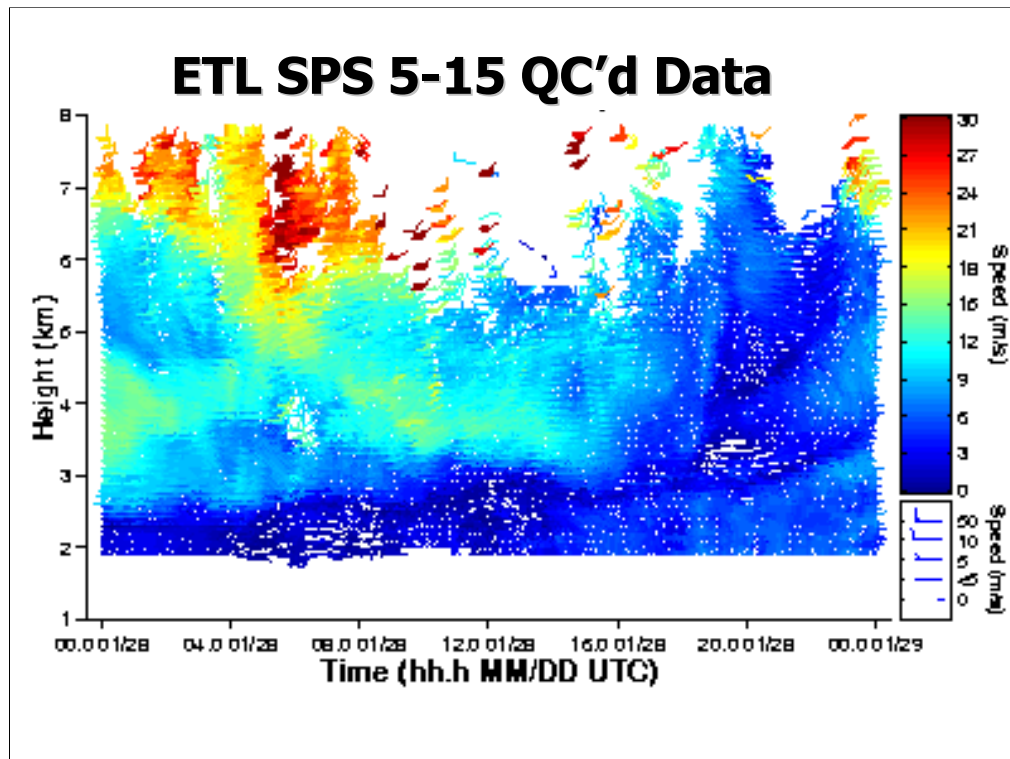
Initial tests of the radar and signal processing were conducted at the Boulder Atmospheric Observatory. The BAO is located 25 miles east of Boulder and centers around a 300 meter tower. The following slides show data at various stages of quality control, and comparisons of commercially available processing and ETL processing.



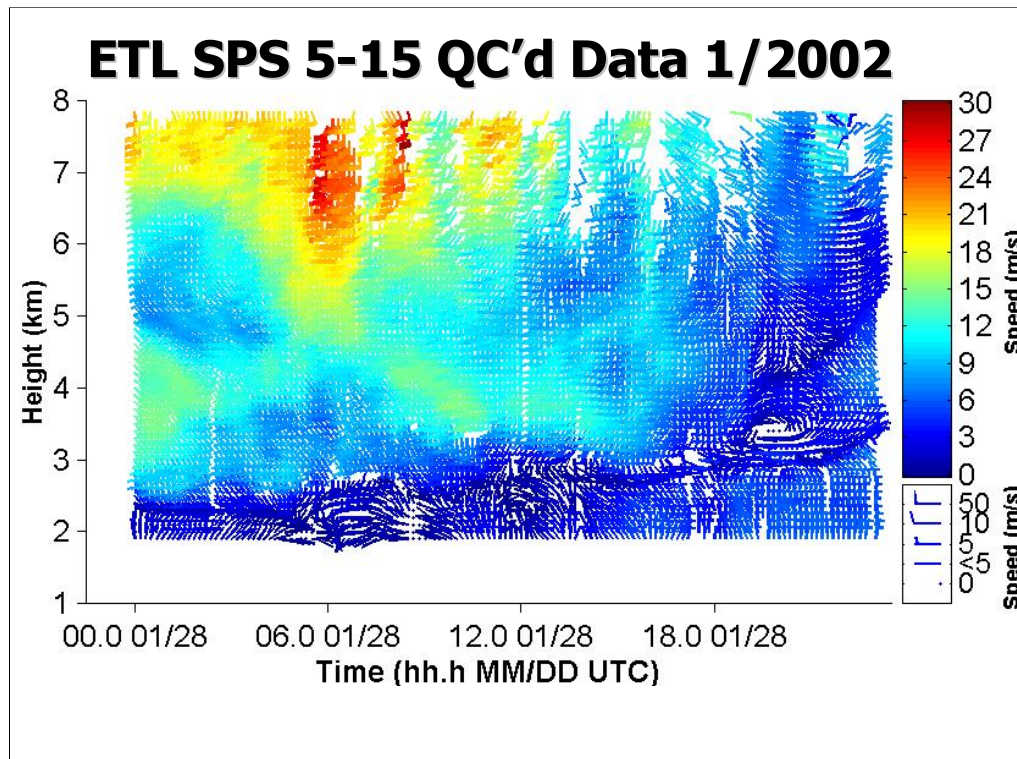
SPS (ETL's advanced Signal Processing System) data, with no quality control- 60 and 30 minute resolution.



CNS (consensus processing, normally used processing method, available commercially), compared to ETL SPS processing. Both with no quality control.

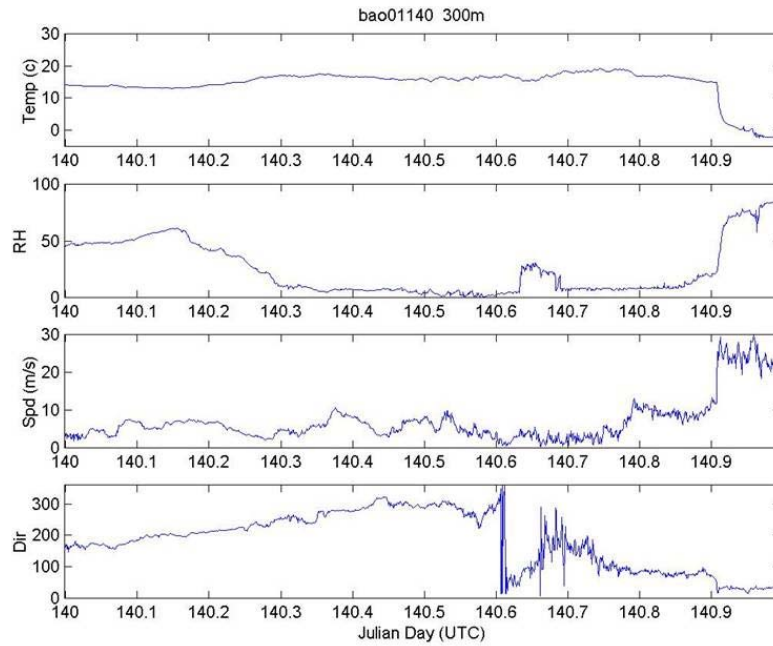


ETL SPS processed data with quality control. Processed for 15 minute averages and 5 minute updates. Software as of Jan 2001 (see next slide).

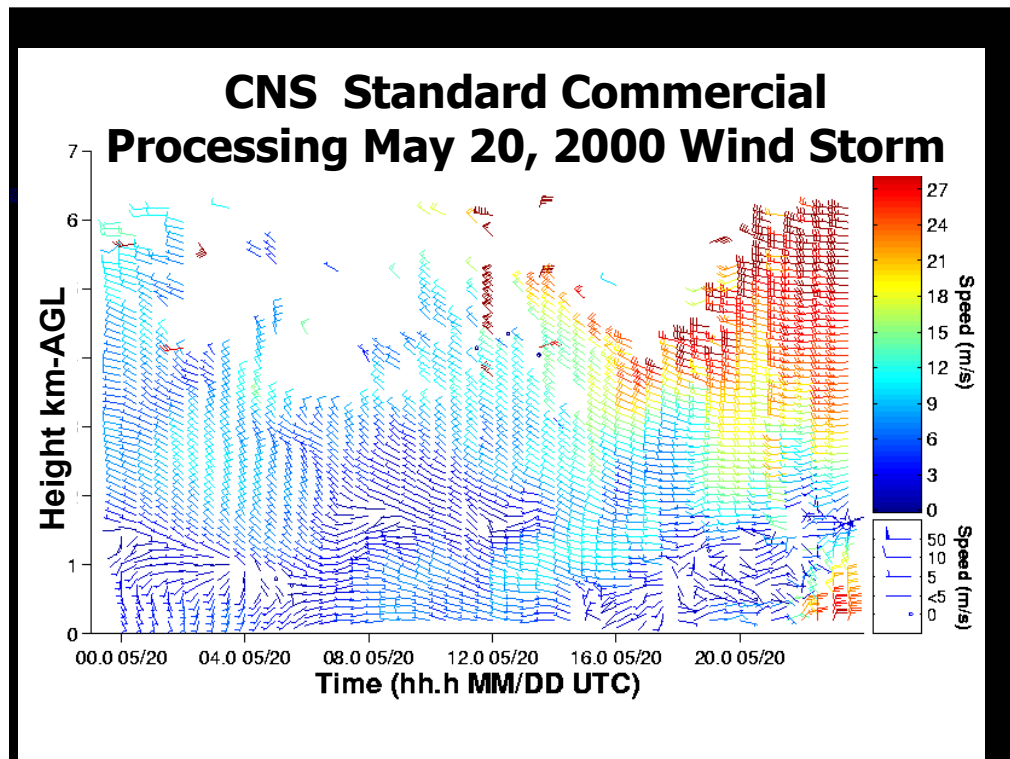


ETL SPS processed data with quality control. Processed for 15 minute averages and 5 minute updates. Software as of Jan 2002 (see previous slide). The SPS software was improved over the course of the previous year.

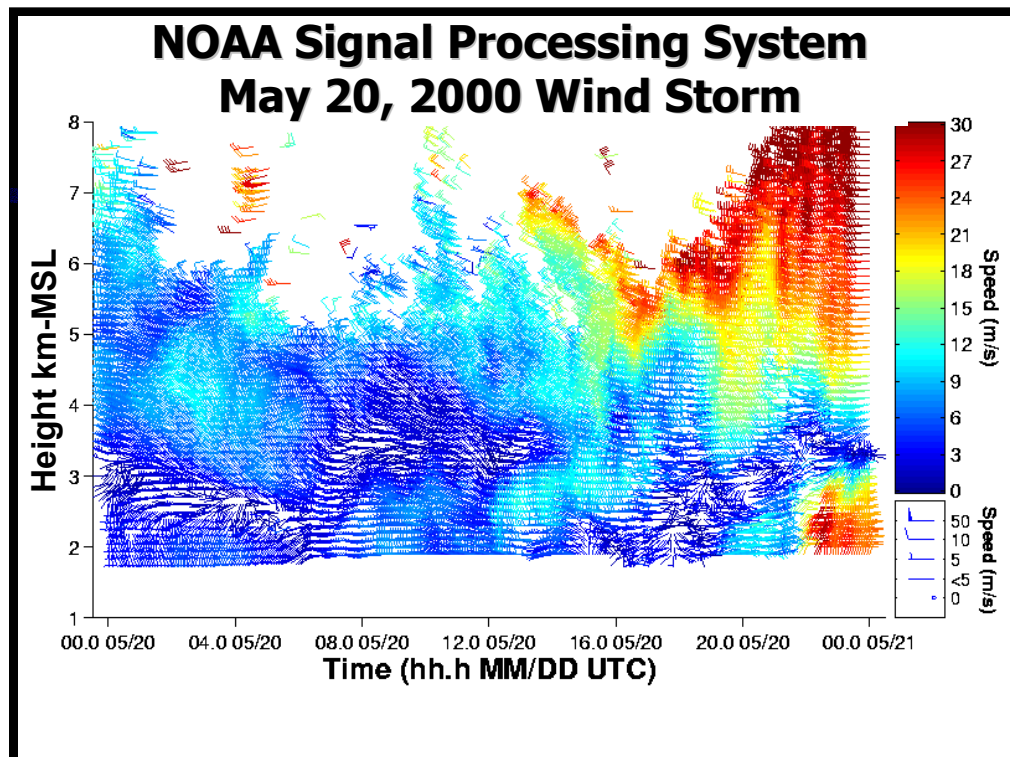
BAO 300m Data, May 20, 2000



Temperature, humidity, and winds from 300 meter tower.



Winds produced by commercially available software. Compare with following slide.



Winds produced with ETL advanced signal processing.

Testing and Validation at Ft Huachuca

- **EPG 915 MHz Profiler**
- **Standard CNS vs ETL SPS processing**
 - **EPG 915 CNS, EPG Balloon, FTH CNS, FTH SPS**

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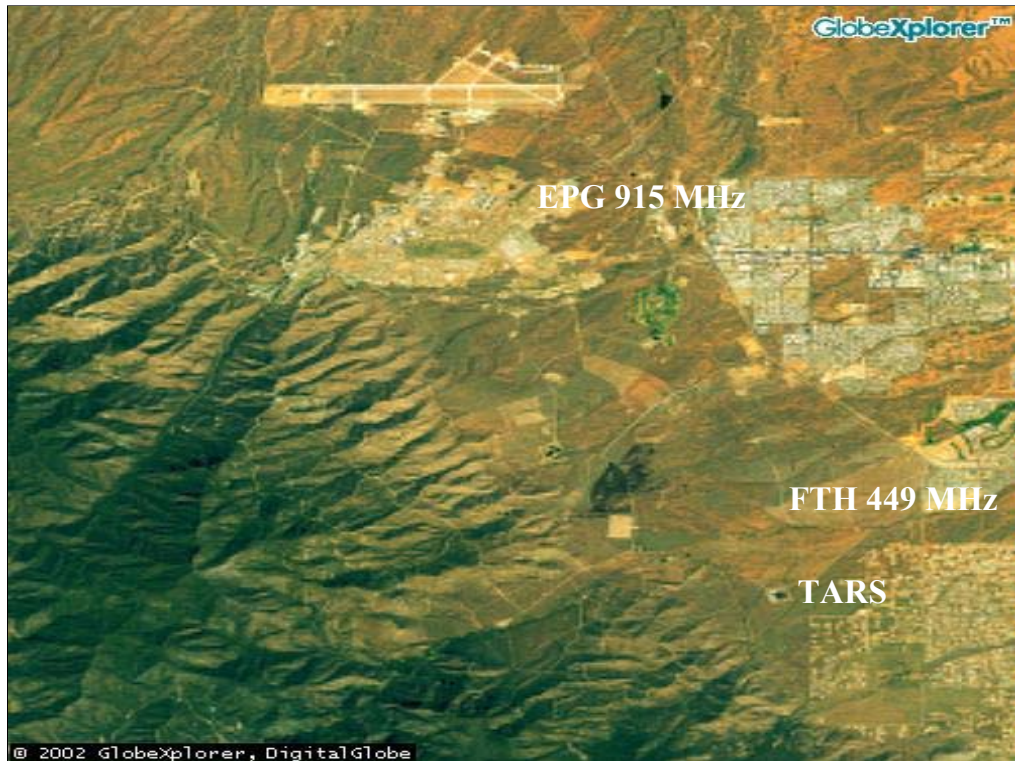
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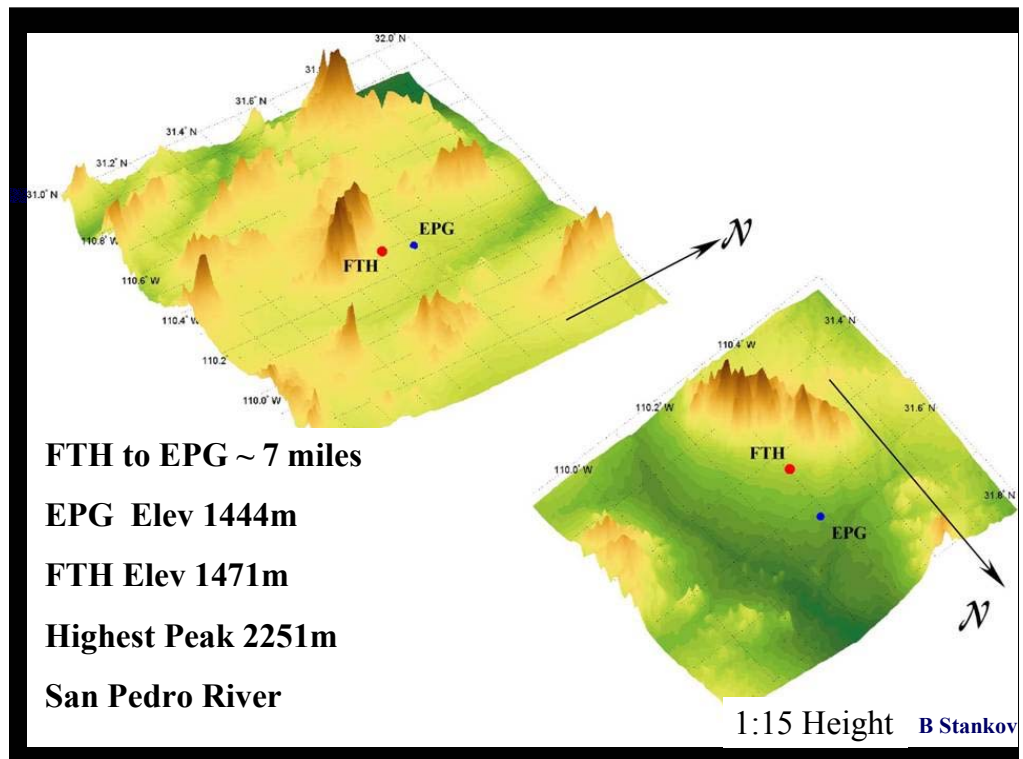
After installation, the Ft. Huachuca profiler was compared with local observations and models. A more extensive validation will be conducted throughout the year as other comparison data becomes available.



Satellite view of TARS site (as available on Mapquest).



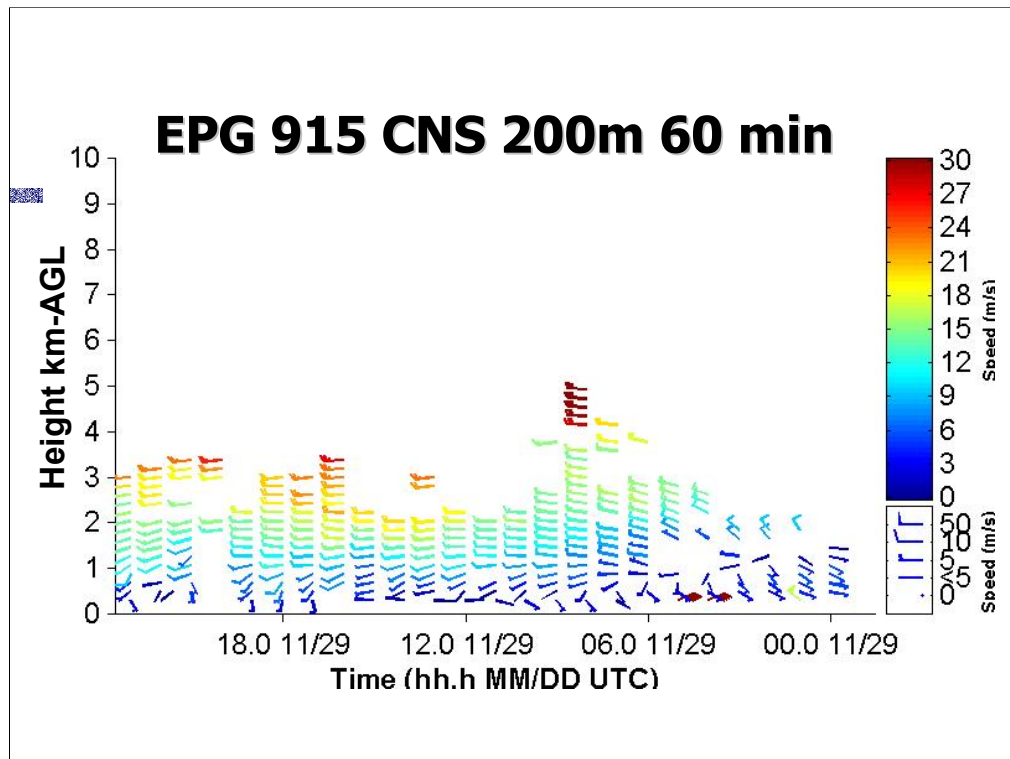
Satellite view of Ft. Huachuca showing location of Army EPG 915 MHz radar wind profiler, the 449 MHz radar wind profiler and the TARS site.



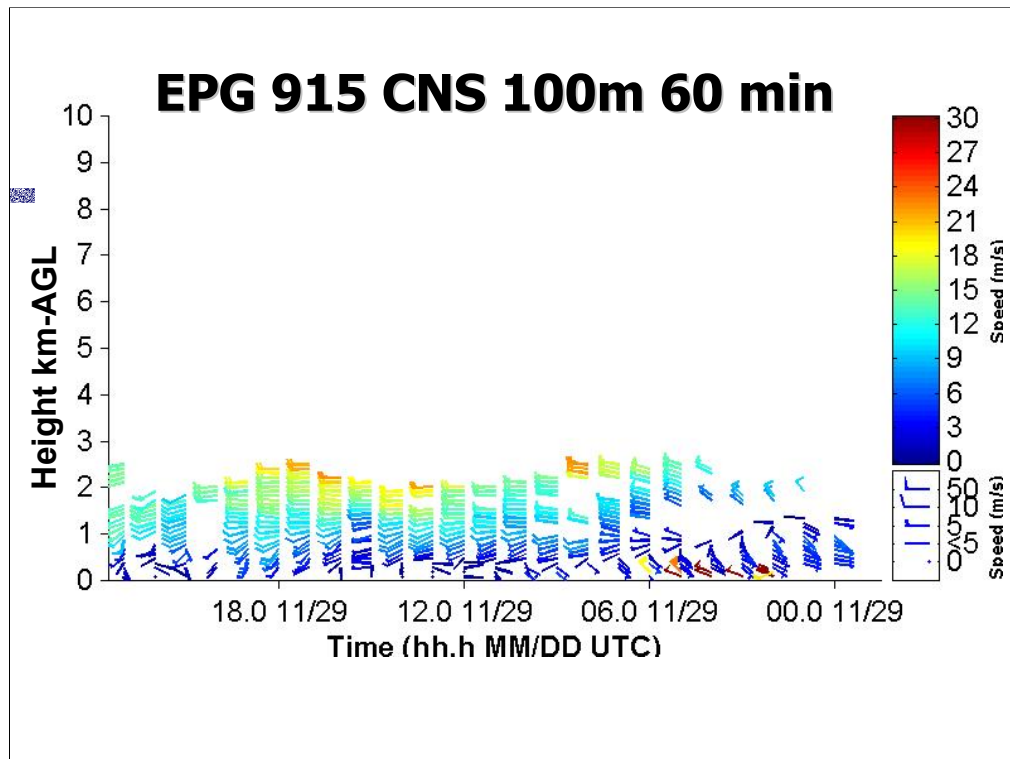
Exaggerated view of topology at Ft. Huachuca. Portrays why wind comparisons between 449 and 915 radars, and radiosondes released from EPG site might not always agree.



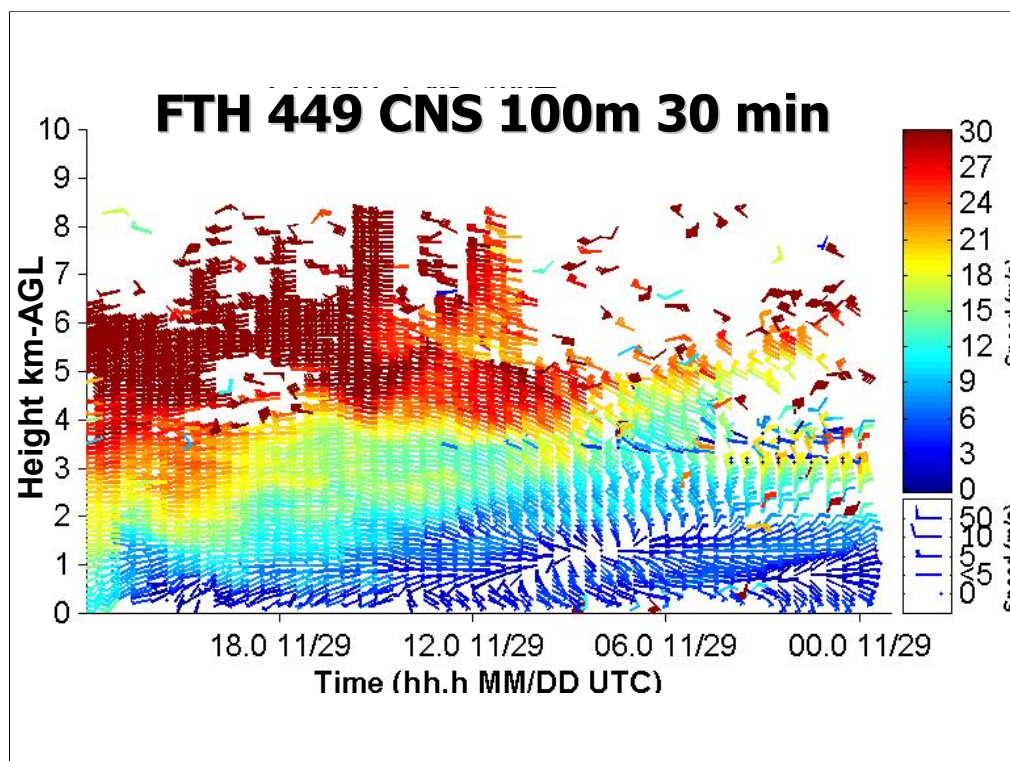
Pictures of both profilers with mountains in background.



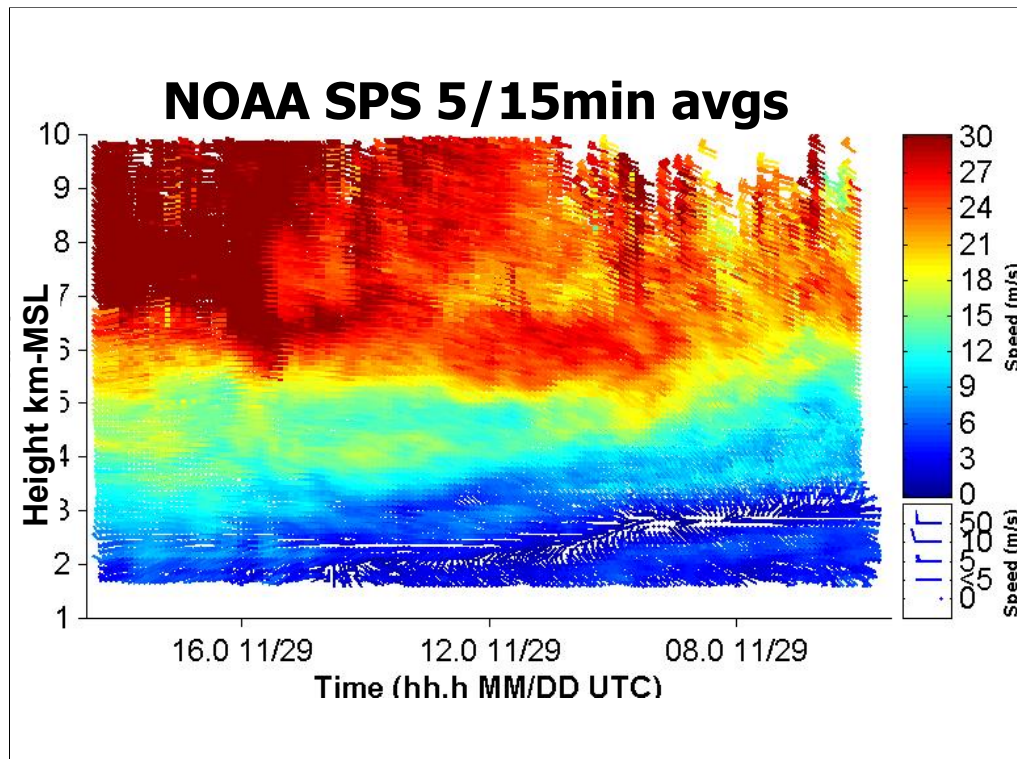
Data from EPG 915 MHz radar wind profiler, for 200 meter mode, 60 minute averaging



Data from EPG 915 MHz radar wind profiler, for 100 meter mode, 60 minute averaging

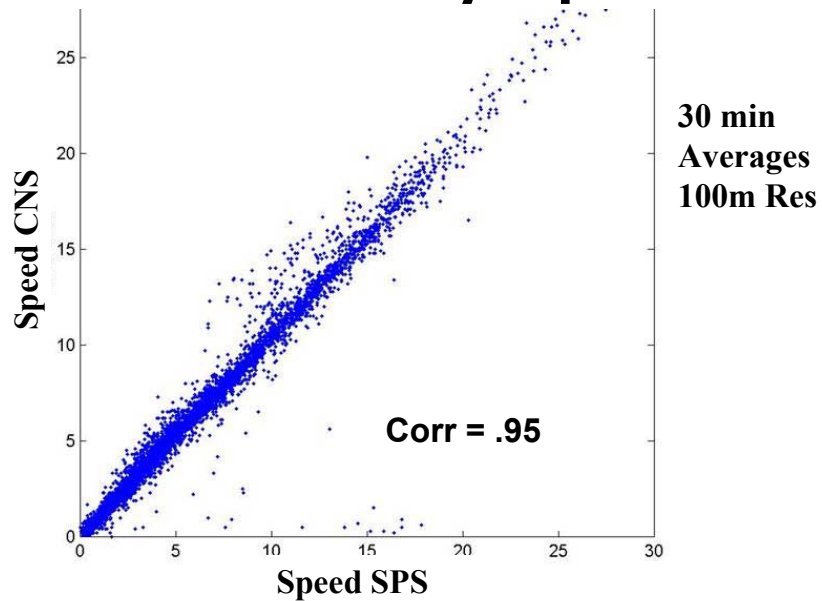


Data from Fth 449 MHz radar wind profiler, 100 meter mode, 30 minute averaging, using standard CNS processing, with no QC.



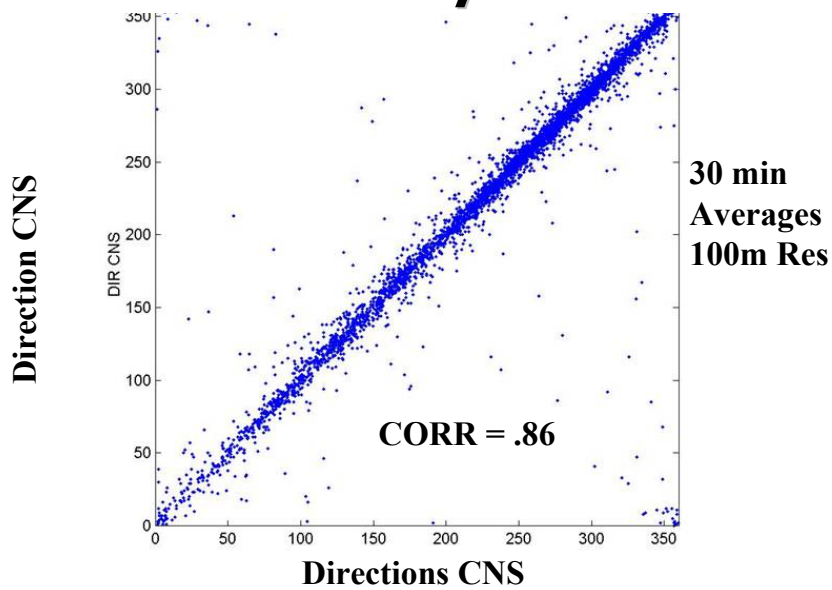
Data from FtH 449 MHz radar wind profiler, 100 meter mode, 30 minute averaging, using ETL SPS processing, with QC. 15 minute averages with 5 minute updates.

CNS vs SPS 6 Days Speed

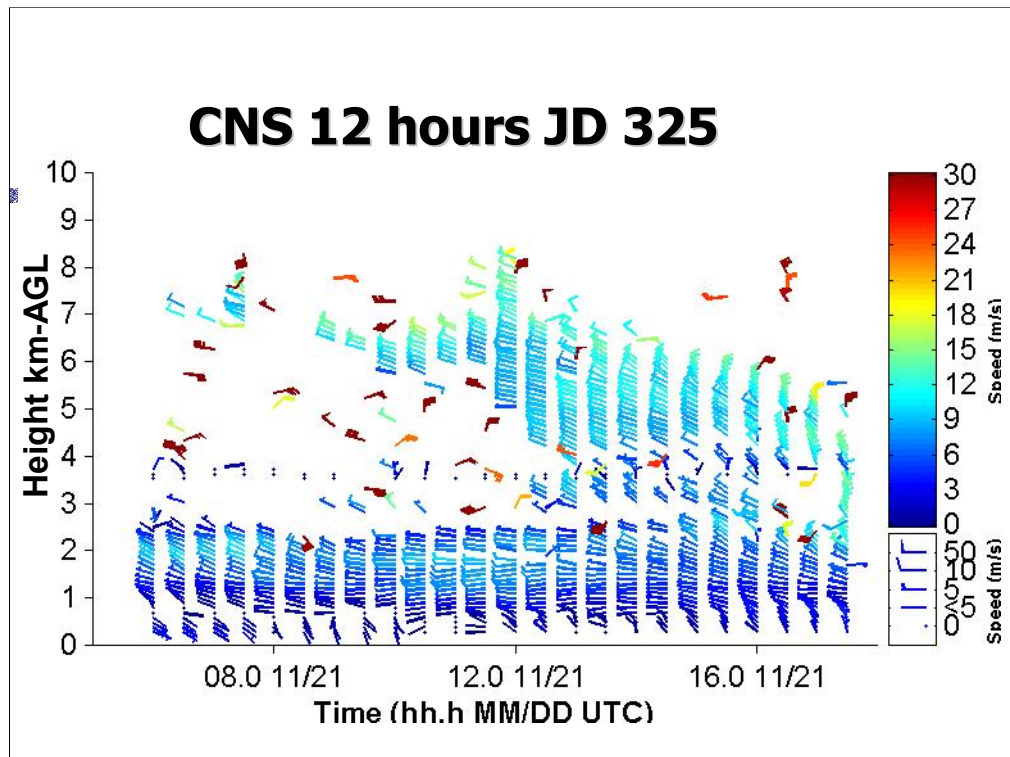


As a first validation of wind data, the new ETL processed wind data can be compared with the same data as processed with commercially available software.

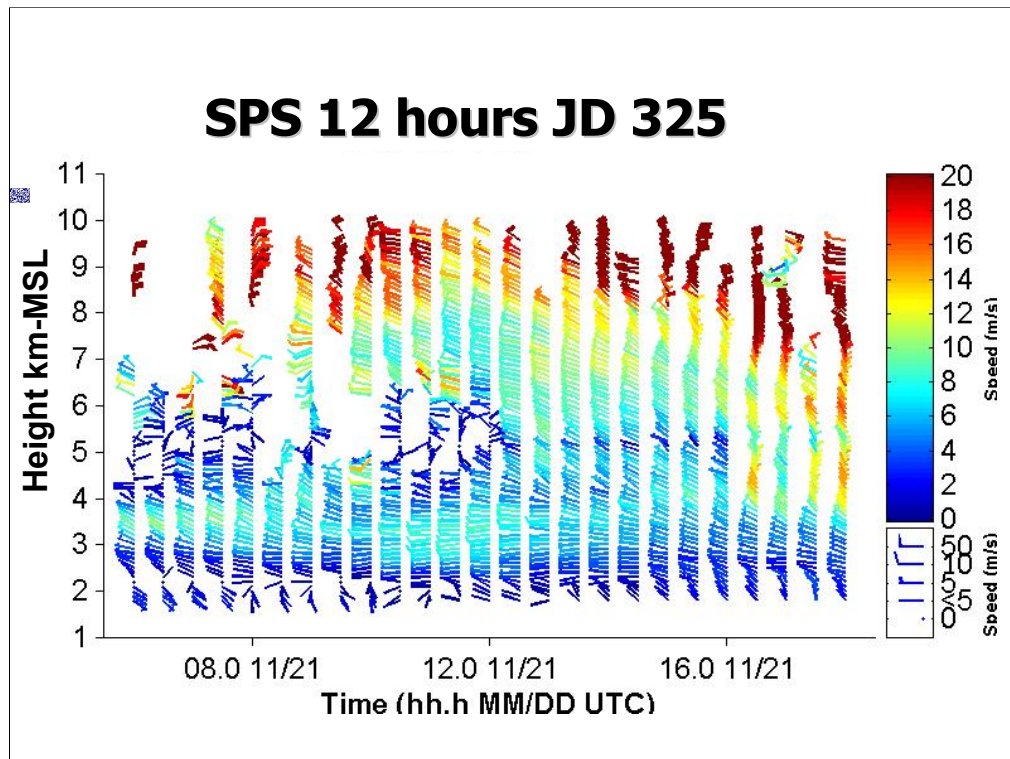
CNS vs SPS 6 Days Direction



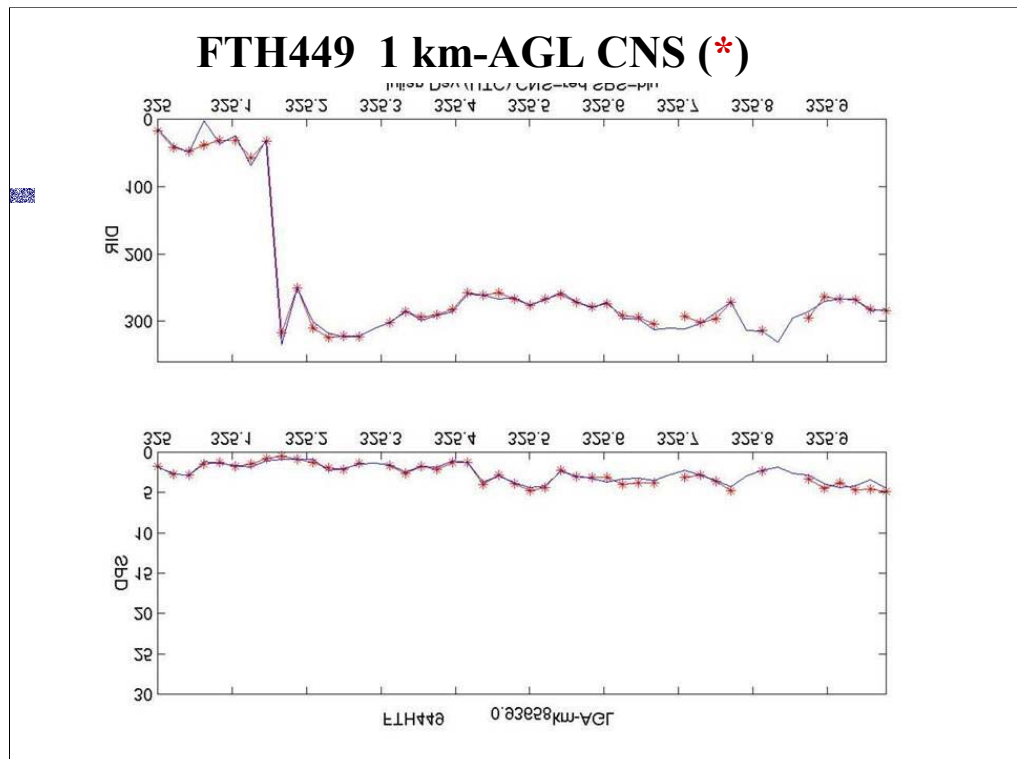
As a first validation of wind data, the new ETL processed wind data can be compared with the same data as processed with commercially available software.



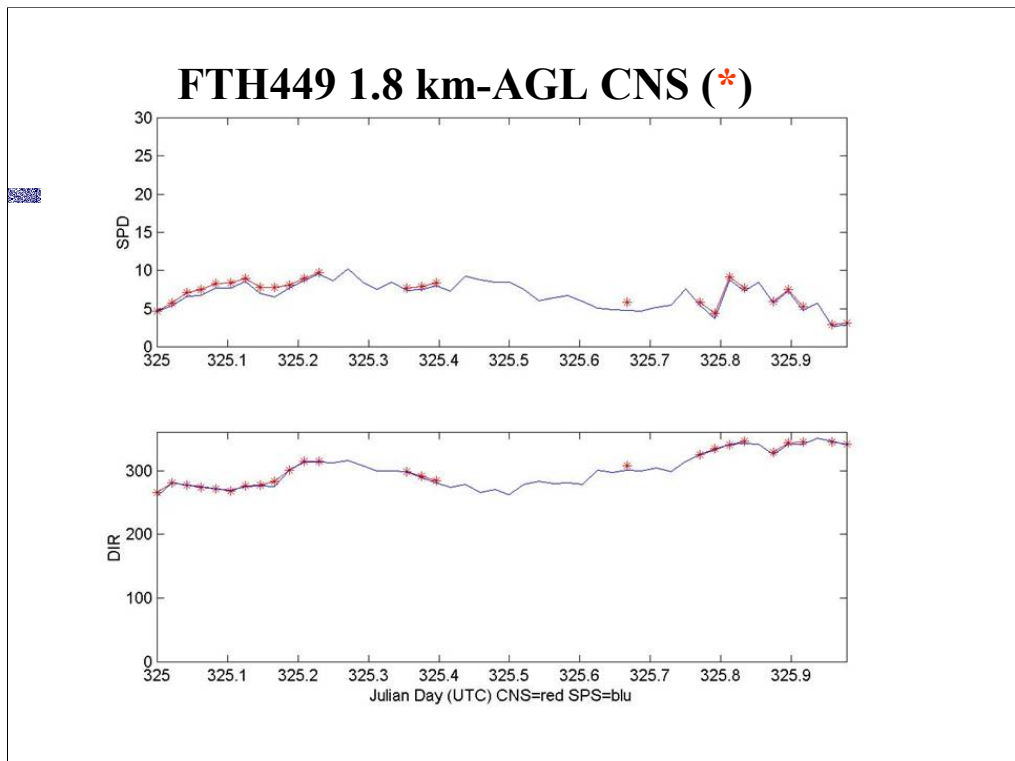
Standard CNS processing (see next slide)



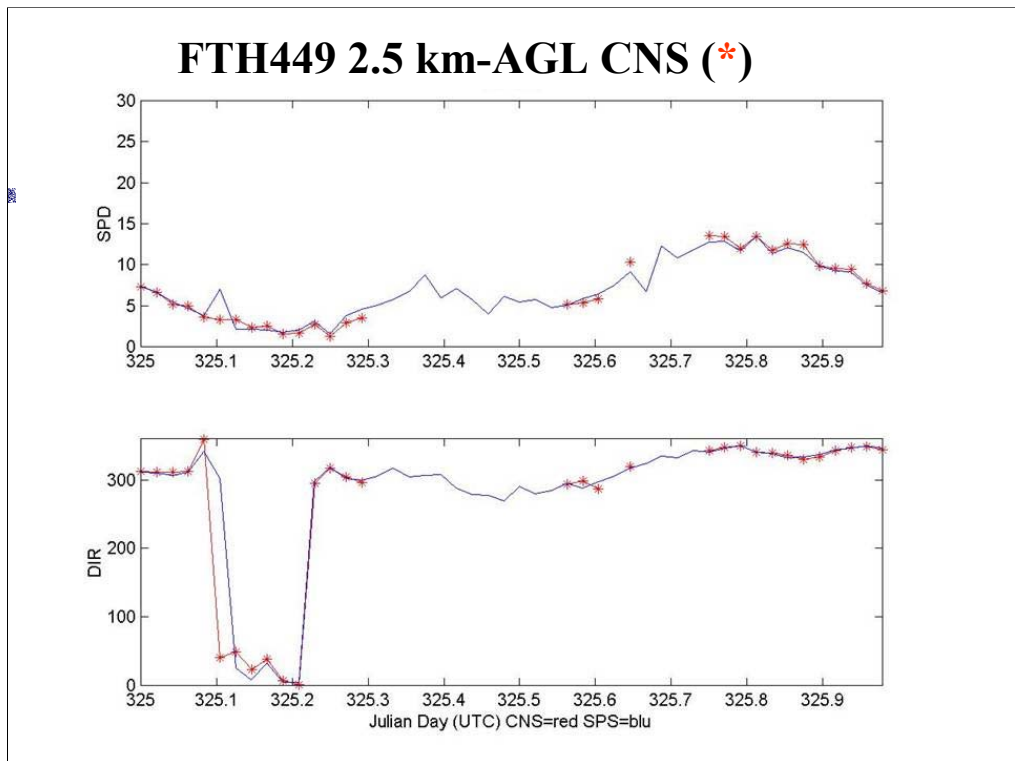
ETL Advanced SPS processing (see previous slide)



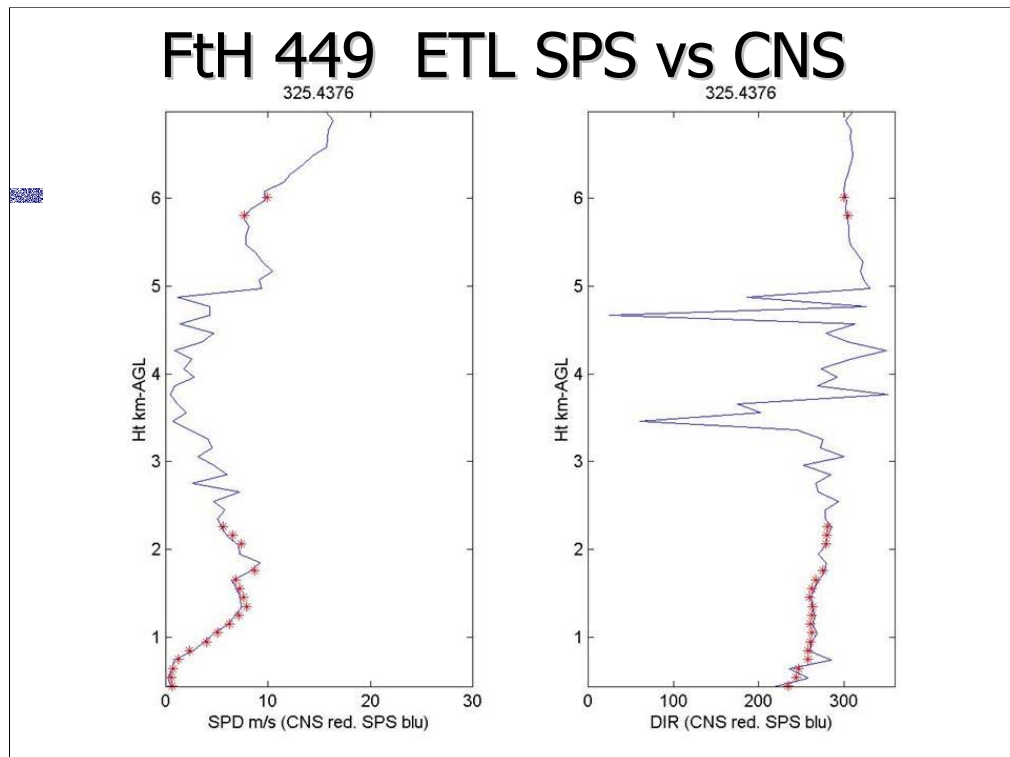
Horizontal “cut” of wind data. Comparison of ETL SPS versus CNS



Horizontal “cut” of wind data. Comparison of ETL SPS versus CNS

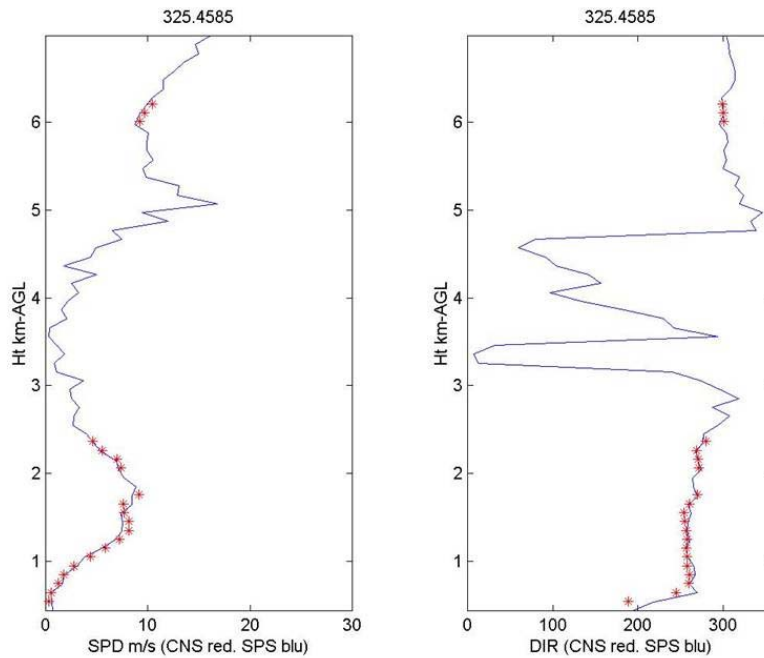


Horizontal “cut” of wind data. Comparison of ETL SPS versus CNS



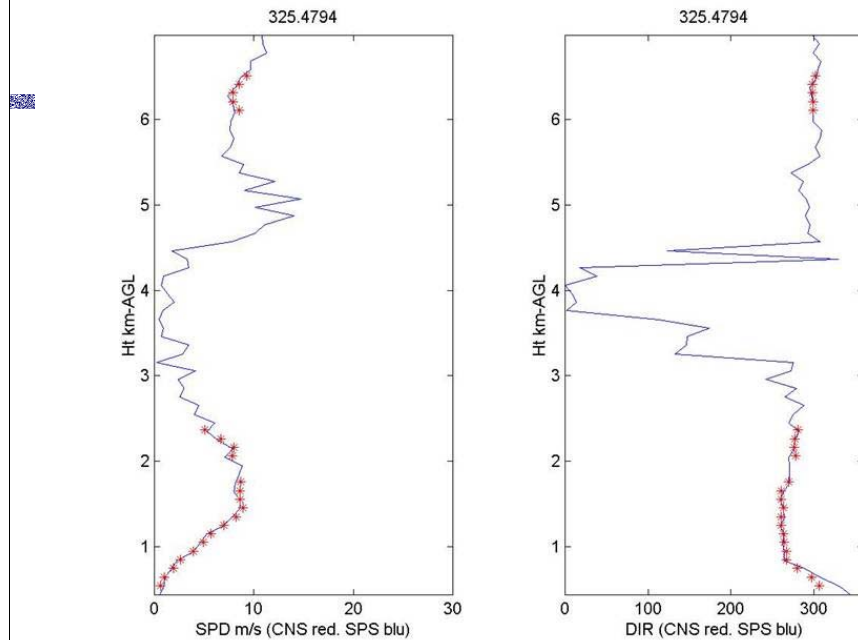
Vertical profiler of wind data. Comparison of ETL SPS versus CNS

FtH 449 ETL SPS vs CNS



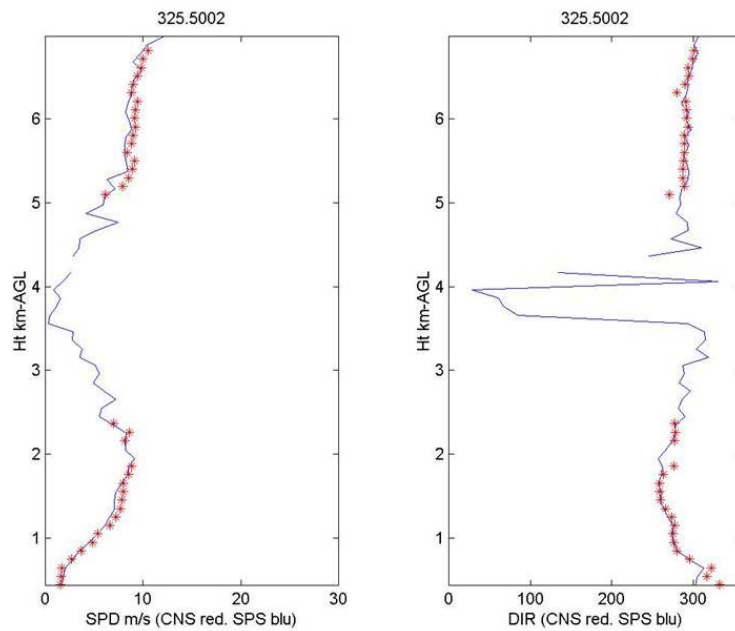
Vertical profiler of wind data. Comparison of ETL SPS versus CNS

FtH 449 ETL SPS vs CNS



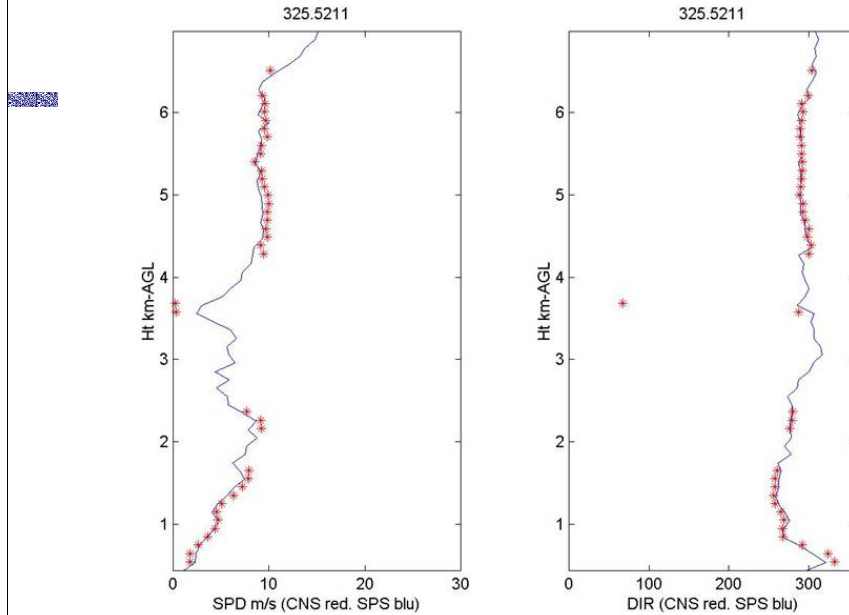
Vertical profiler of wind data. Comparison of ETL SPS versus CNS

FtH 449 ETL SPS vs CNS



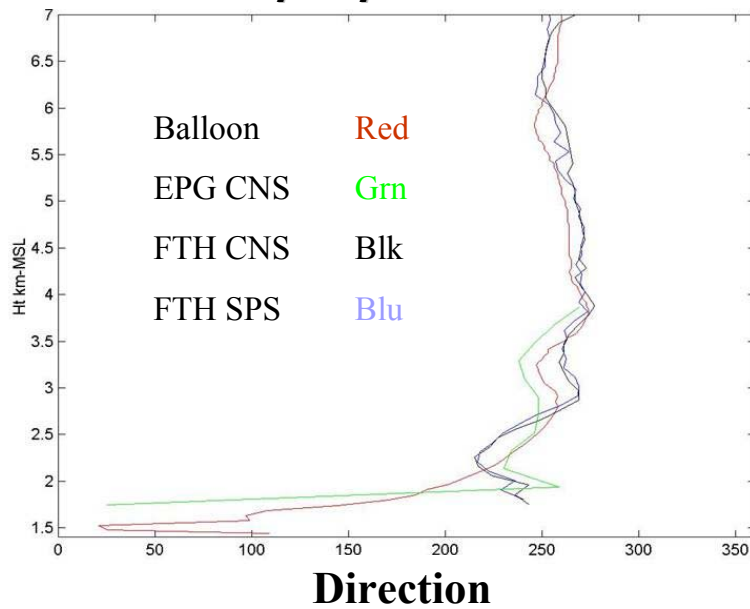
Vertical profiler of wind data. Comparison of ETL SPS versus CNS

FtH 449 ETL SPS vs CNS



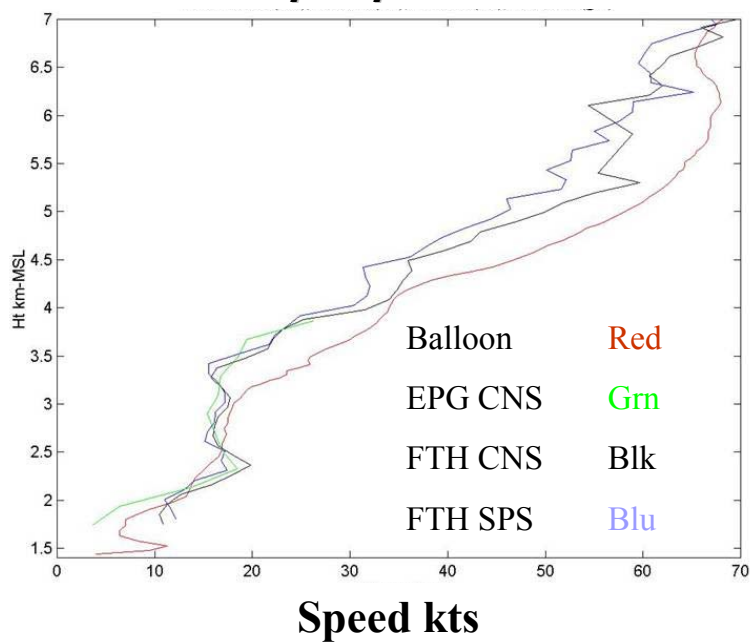
Vertical profiler of wind data. Comparison of ETL SPS versus CNS

Balloon vs Profiler Dir 11/30/2001

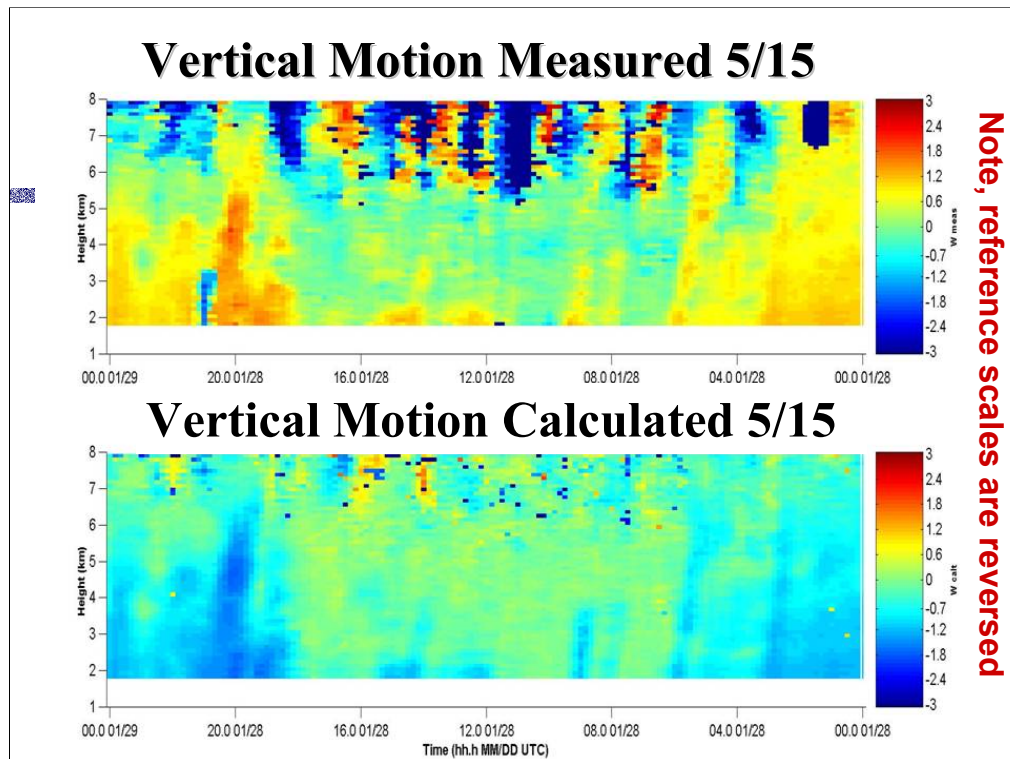


Wind direction comparison of radiosonde, EPG 915 (running CNS), and FtH 449 (processed with both CNS and ETL SPS)

Balloon vs Profiler Spd 11/30/2001

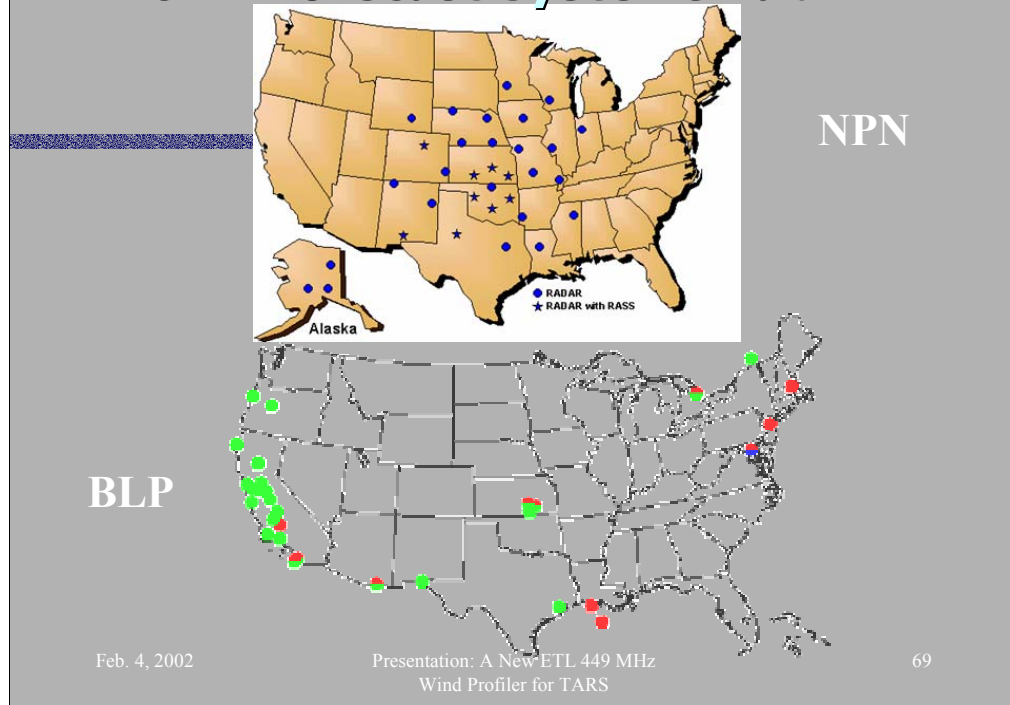


Wind speed comparison of radiosonde, EPG 915 (running CNS), and FtH 449 (processed with both CNS and ETL SPS)



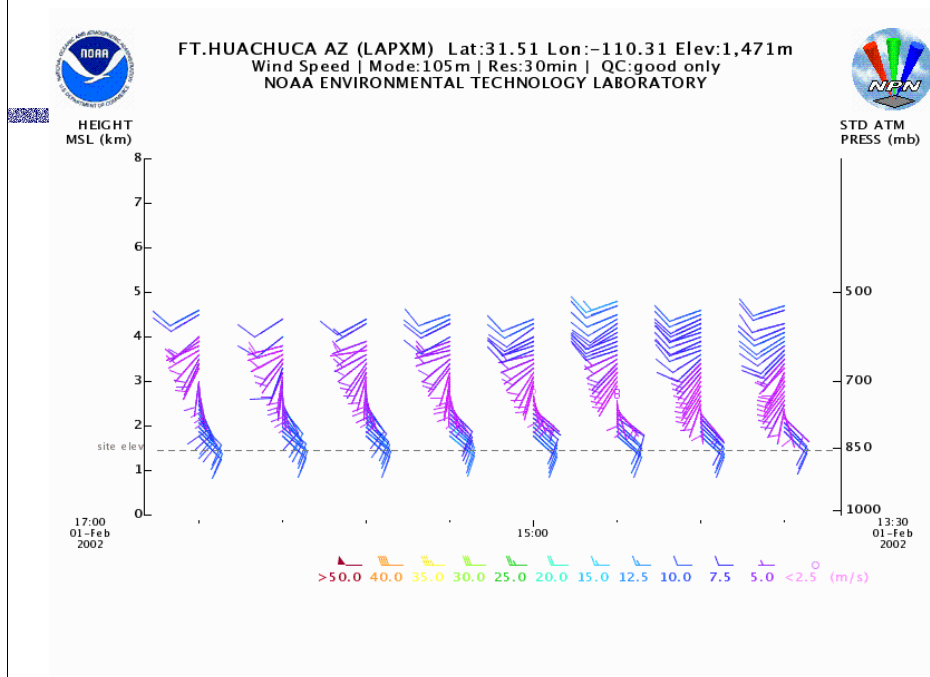
Vertical motion. Top is measured with vertical beam. Bottom is calculated from oblique beams.

NOAA Forecast Systems Lab



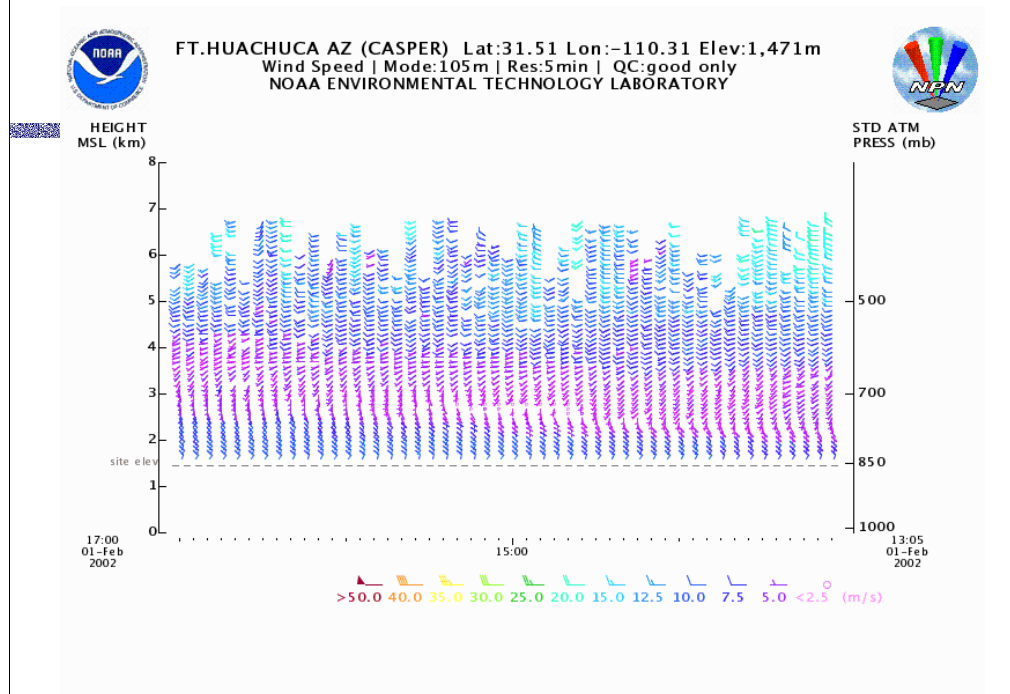
Forecast Systems Laboratory maintains a network of high power 404 and 449 MHz wind profilers, as well as accepting data from wind profilers owned and maintained by other government bodies. Maps show location of FSL 404/449 MHz Wind profiler network, and location of non-affiliated boundary-layer profilers (BLP). All data is integrated into NWS data flow. Data is available on the Internet.

FSL CNS



FtH 449 data as seen on FSL web page, using CNS processing.

FSL SPS

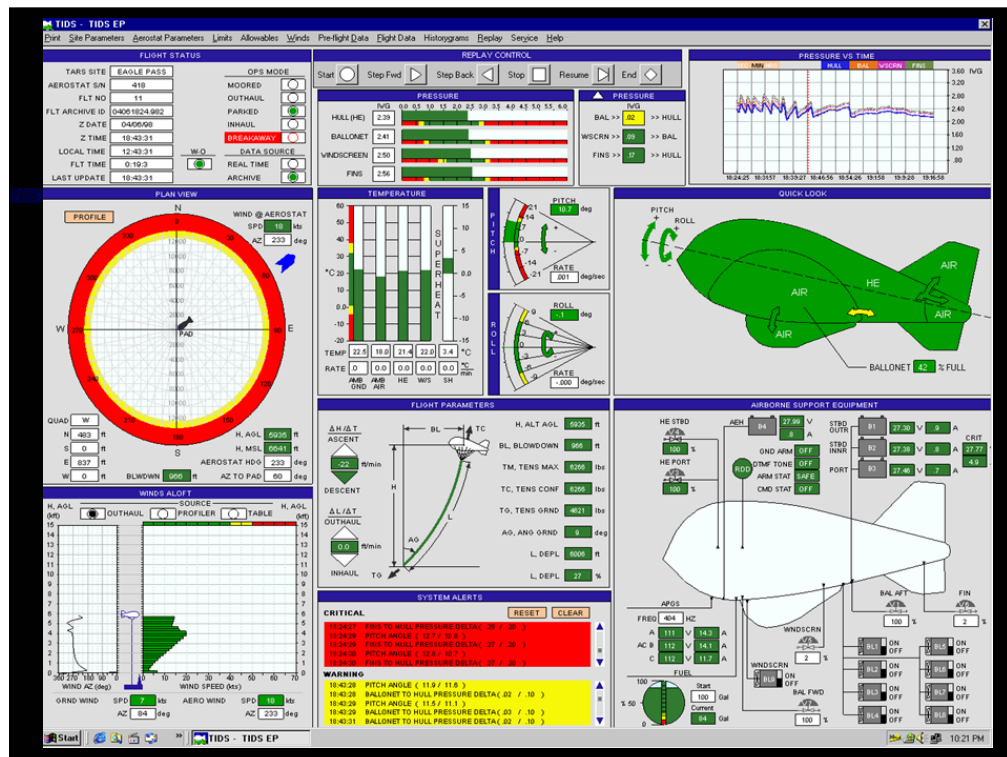


FtH 449 data as seen on FSL web page, using ETL advanced SPS processing.
<http://oak.fsl.noaa.gov/blp/displays/blpus.html>

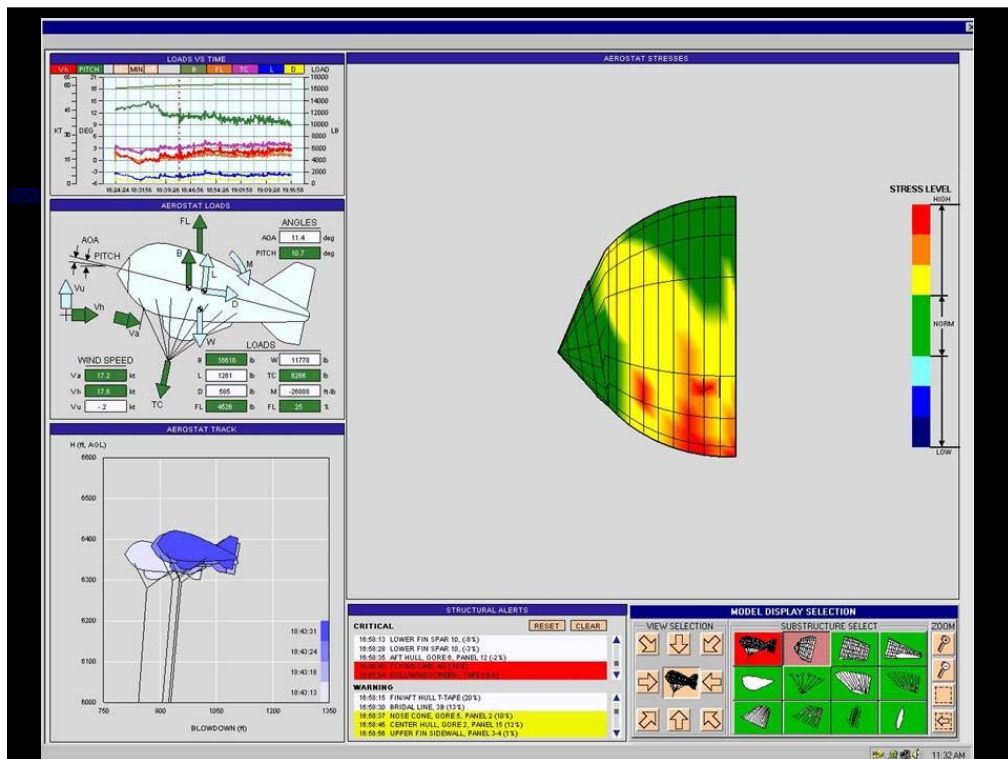
TARS Operations Center



TARS control room with display of wind profiler on left.



Tars Interactive Display System, screen 1. Wind profiler data is ingested and displayed on the lower left and used for stress calculations.



Tars Interactive Display System, screen 2

Future



- **Hurricane Proof System**
- **GOES Link**
- **Continuing Validation**
 - (Ft Huachuca thunderstorm season)
- **Installations at Cudjoe Key, Puerto Rico, "West to East"**
- **RASS and GPS TPWV**

Feb. 4, 2002

Presentation: A New ETL 449 MHz
Wind Profiler for TARS

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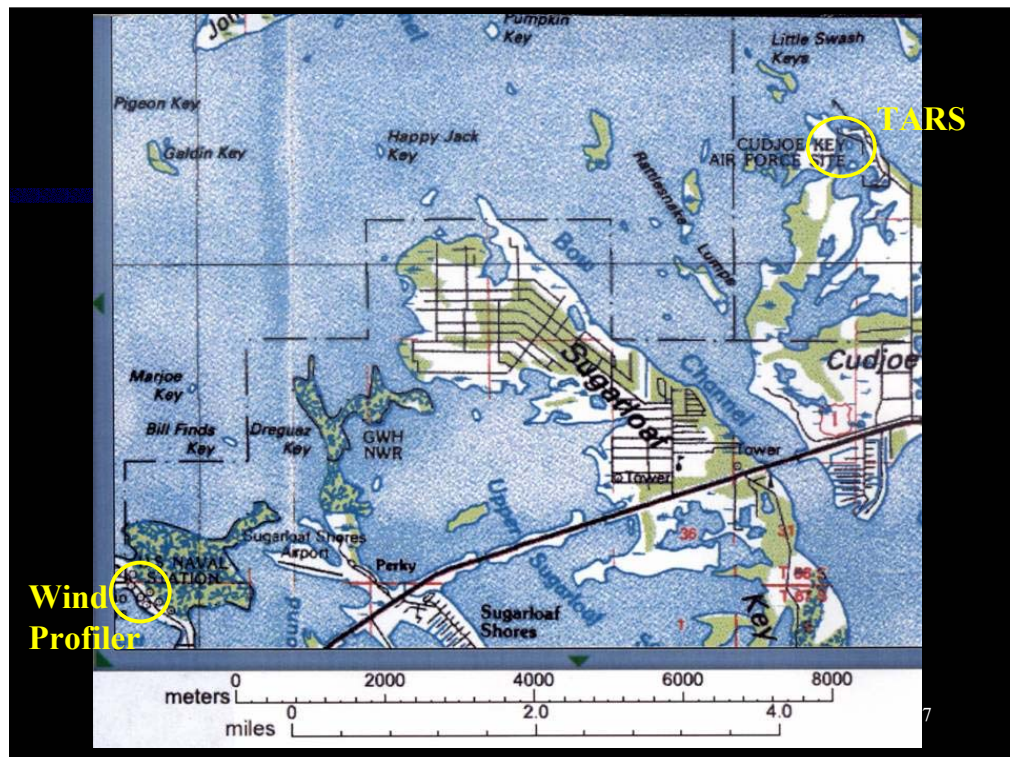
Cudjoe Key, FL Dual Aerostats



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Presentation: A New ETL 449 MHz
Wind Profiler for TARS

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Cudjoe Key, FL. Location of TARS and proposed location of 449 wind profiler.

Navy Communications Site



View of Navy Communications Site, looking toward the North-North-West.



View looking toward the East.



ETL personnel at Ft. Huachuca.